Quality in Spreading

Reducing Impact on Environment by Addressing Precision in Distribution of Ice Control Agent Spreading Technologies

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Title:

Quality in Spreading – Reducing Impact on Environment by Addressing Precision in Distribution of Ice Control Agent Spreading Technologies

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Abstract:

Traditional technologies in spreading ice control agents cause a considerable waste of salt. Measurements of spreading quality indicate that half the amount of ice control agents consumed do not have any effect on winter maintenance. The effect is illustrated by a scenario.

Simple salinity measurements are used to find the distribution of salt across a road-section. The spreading quality is expressed as the standard deviation of the waste of salt due to imbalance between the lanes in the spreading patterns, while it is assumed that spreaders can be adjusted to eliminate systematic bias.

The road authorities should focus on the spreading quality when ordering new spreaders, they should be aware of the stability in the spreaders adjustments, and they should introduce simple tests to verify that the adjustment, and thus the spreading quality, of each spreader is remained.

Only this way will it be possible to reduce the enormous unnecessary impact on the environment. In addition, the costs will be reduced as well.

Keywords:

Ice Control. Spreading Quality. Highways. Denmark.

INTRODUCTION

Environmental impact form Ice Control Agents

Ice control agents, such as salt, are alien elements to the surroundings of the highways. Once spread the agents will, sooner or later, end up aside the road, either in the drainage systems or on the ground. Here the agents represent an unwelcome impact on the environment. The impact is massive, and some of it is not necessary.

During the winter 2008-2009 an amount of 49.7 Mg (54.8 T) of sodium chloride (*NaCl*) was spread on the 3,700 km (2,300 mi) national highways in Denmark (1). This corresponds to 1.30 kg pr. m^2 (0.27 lb pr. ft^2) road-surface or 13.42 kg pr. meter (9.02 lb pr. feet) highway.

The visual effects of the presence of the salt are changes in the vegetations on the road-sides, where halophytes such as sea pink (*Armeria maritima*) and sea plantain (*Plantago maritima*) will gain ground. More crucial is that salt ending up on the ground may eventually be transported into the underground where the salt may perform a threat to the ground water resources.

Ice control is a *must*, and the use of ice control agents is inevitable. But bearing the consequences on the environment in mind ice control should be planned and carried out in a way where the risks of the cumulative effects are reduced as much as possible. Focusing on the spreading quality is essential in this context.

Basic Distribution of Ice Control Agents

In order to achieve the planned effect from ice control agent spread on the highways it is important that the materials are actually distributed as intended across the cross-section of the road. If not, the material will not be able to prevent ice on the road.

The basic distribution – i.e. the distribution of salt on the cross-section immediately after the spreader has passed – is of course crucial for the successful ice control activity. It will depend upon the equipment used for the spreading and upon the operation of the equipment – e.g. speed, dosage and width of the target area of the spreading.

Other parameters than the basic distribution do, however, influence upon the distribution being actually effective in the ice control. Various redistribution processes takes place after the spreading: Wind and the turbulence from the traffic on the highway will blow off some of the materials. Wheels will mix the materials into the snow and ice and will thus speed up the melting process. The melted solution as well as rain will transport the materials towards the lower areas of the road surface. All these activities mean that salt is removed from the road surface.

The additional effects make it difficult to isolate the basic distribution. One must bear this in mind when dealing with measurements of the distribution of salt on a “real life” road.

Initial Studies in the County of Funen

Studies carried out in the winter season 1998-1999 by Fyns Amts Vejvæsen (FAV) – i.e. the Highway and Transportation Division in the former County of Funen, Denmark – and the Danish National Road Directorate proved brine to be an interesting ice control agent compared to pre-wetted salt: A significant higher percentage (90%) of the brine-spread salt were found still to be present on the road surface 2-10 hours after spreading compared to the use of pre-wetted salt

(65%), and the residual brine-spread salt seemed to have a more uniform distribution across the cross-section (2).

Studies carried out in the winter seasons 2000-2002 on the national motorway E20 across Funen showed that in hoar frost situations the use of brine instead of pre-wetted salt enabled salt savings of at least 30% (3). In snow situations it was found that the motorways' slow lane (with the heavy vehicles) needed lesser salt than the fast lane with the light traffic. This finding was almost a result of serendipity: The gritter used for the pre-wetted salt had by fault an unbalanced distribution spreading more to the left lane. However, because of the result it was decided to un-balance the dosage on motorways so the slow, right-hand lane got 40% less sodium-chloride (*NaCl* – brine or pre-wetted salt) than the fast, left-hand lane.

FAVs conclusions from the studies were that the "quality" of the spreading was more important than expected, and that there seemed to be room for improvements. FAV found that it would be possible to reduce the consumption of salt considerably by using brine-spreading technologies; however the technologies available were still to be improved.

Implementing Brine Spreading Technologies

Over a period of years FAV conducted tests of a number of spreaders in order to evaluate the quality of their spreading abilities. FAV also invested in brine mixing plants, ordered new spreaders using nozzles for brine-spreading and redesigned the ice control-routes. In the winter season 2005-2006 FAV were finally able to totally phase out the use of pre-wetted salt on the county highways and thus reduce the salt-impact upon the environment by more than one third without jeopardizing traffic safety and at the same costs as using pre-wetted salt (4) (5).

During this process FAV had to establish procedures to evaluate the "quality" of the spreaders' distribution and to interpreting these results. The measurements thus provided inspire, by second thought, to consider how to define the "quality"; the main purpose of this paper is to share some of these considerations.

MEASUREMENTS OF SPREADERS DISTRIBUTION-PATTERN

Measuring Procedure

FAV's tests and measurements of spreaders' distribution were carried out during the summer and autumn 2004 with supplementary measurements of new spreaders in the autumn 2005. All measurements were carried out on the same section of a county highway. A section with four lanes divided by a central reserve was used. Traffic was counted in 2004 showing 817 northward and 1394 southward bounded vehicles during the 4 hour period 0600-1000. The tests were conducted in the morning; spreading took place at 6 o'clock, and measurements began at 8 o'clock. The effect was that peek-hour traffic was almost not disturbed by the spreading activities, and yet had contributed to a redistribution of the salt across the road sections. This redistribution is assumed to simulate what happens in "real life" winter actions.

The road was divided into 10 subsections, each 400 meters long (sections of 200 meters were originally planned, but turned out to be too short to ensure correct operation when changing the spreading-pattern from one subsection to another). Half of the subsections were placed on the lanes with northbound traffic, the other five subsections on the southbound lanes. Side slope varied from 2,5% to 4,0% due to the curvature of the section, and in each direction measurements were taken where three cross-sections inclined to the right ant two to the left.

Staff from the manufactures that had provided the spreaders adjusted their spreaders before measurements took place. Each subsection was treated with salt (brine or pre-wetted salt or both) according to a specific plan set up for the individual spreader in order to get results from combinations, being representative for the use of the particular spreader, of speed and spreading width. Pure water was spread in order to have a wet surface before spreading of the salt.

Measurements were taken with five portable salinity testers (SOBO 20) according to a detailed instruction (6). Residual salt was measured at cross-sections 20-40 meters before the end of each subsection in order to avoid the influence from traffic bringing salt from the previous subsection (with a different spreading-pattern).

At each subsection five cross-sections with a distance of 2 meters (6½ ft) were measured, and in each of these cross-sections measurements were taken by every 0.5 meter (1.6 ft). Measuring points were indicated with yellow dots on the pavements, see figure 1. In this way each salinity tester contributed 16 measurements in each subsection.

FIGURE 1 Measurements with SOBO20 portable salinity testers, at each subsection five cross-sections 2 meters apart were measured by every 0.5 meter.

Interpreting Measurements

An average of the five measurements in the same distance from the centerline, e.g. 0.25 meters (0.8 ft) left of the centerline, was used as an expression of the residual salt. The results were presented in diagrams, and were documented in eight reports, one for each of the spreaders tested.

The reports were available at the county's website until the close down of the Danish counties, but can now be accessed again (7)…(15).

Figure 2 shows the results from similar spreading with three different spreaders, all using a rotating plate. None of the distributions shown are good – yet the question arises: Which one is the best? And the question does not become easier to answer, when one considers all 10 distributions measured for each spreader. One spreader will perhaps prove advantageous in one situation, but will lack quality in others. This is a demonstration of the difficulties the road authorities have to deal with.

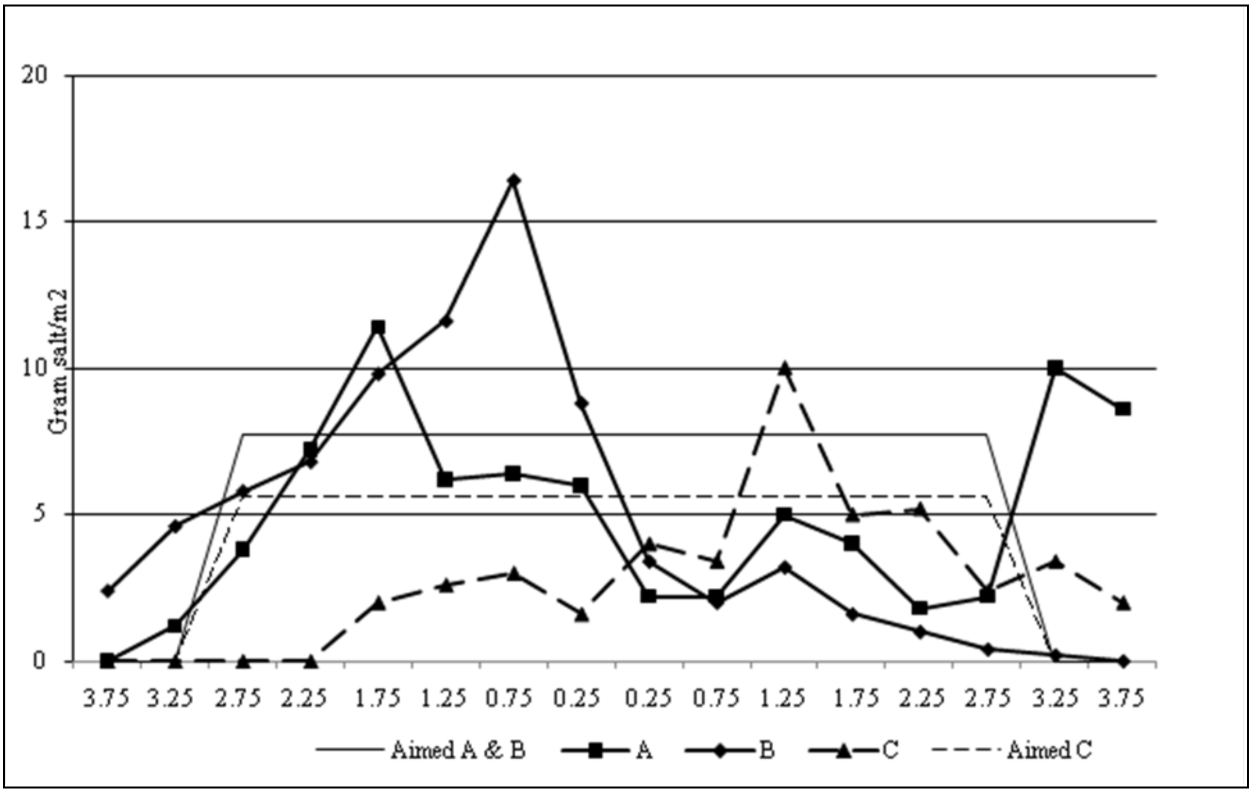

FIGURE 2 Spreading pattern from three different spreaders: A, B and C, all spreading by using a rotating plate. Spreading width is 3 meters on each side of the road centre line, total 6 meters. Spreaders A and B are spreading 10 gram pre-wetted salt (7.7 gram *NaCl*) per m^2. Spreader C is spreading 10 millilitre brine and 3 gram salt (5.6 gram *NaCl*) per m^2. Note that spreaders A and B are rotating counter clockwise and overdose to the left, while spreader C rotates clockwise and is imbalanced to the right. Neither of the spreaders provide satisfactory spreading pattern. Based on references (7), (8) and (9).

FAV interpreted the diagrams visually by looking upon the amount of salt measured in each subsection on each lane and outside the two lanes. The procedure was found to be useful and test measurements were adopted in FAVs specifications when asking for tendering bids for new spreaders. As it turned out, the bid giving the best distribution was using nozzles to spread brine.

ANALYSIS OF WASTE OF SALT

The visual interpretation of the diagrams was found to be adequate for FAVs practical decision-making purpose. However, the measurements adapted from the tests calls for an attempt to establish a more explicit definition to express the quality of the spreading-patterns of the spreaders.

One way to do so is to look upon each subsections distribution of salt measured on the two lanes. Doing so, one can calculate A) salt spread **and** measured outside the target area of the road surface, and B) salt overdosed in the super-supplied lane, providing that the lesser supplied lane has received exactly the amount of salt required, see figure 3 (if the lesser supplied lane does not have the amount of salt required, the lane will be icy, and when distributing salt next time the targeted dosage will have to be higher). Both these numbers represent a waste of salt.

Unfortunately the measurements carried out by FAV, do not allow calculating in the same way salt spread on the surrounding ground outside the two lanes and thus not measured.

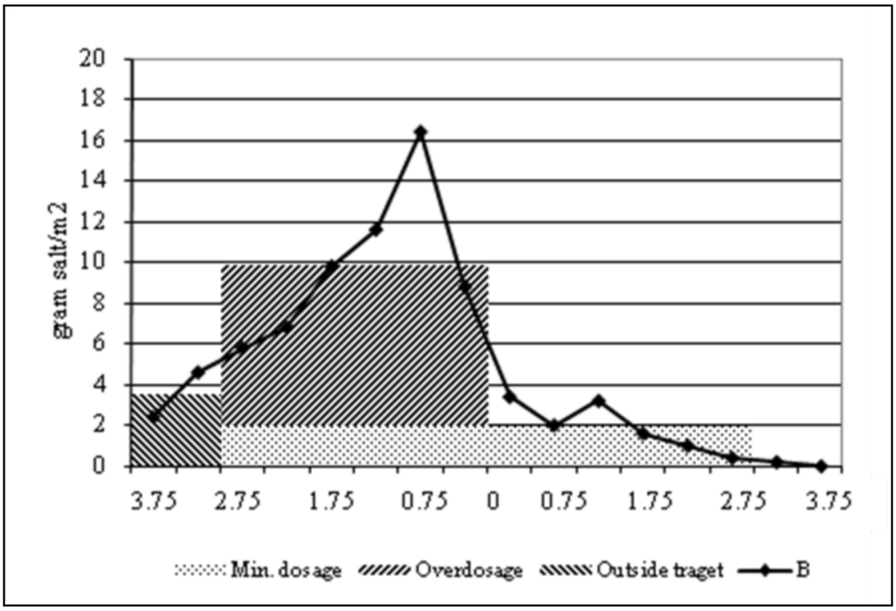

FIGURE 3 An analysis of the spreading pattern from spreader B (from figure 2) shows that the right-hand lane have had 2 gram/m^2. Provided this is exactly the amount required, then only one third of the salt measured within the target area will be of effect to the ice control, while the remaining 67% is overdosed in the left lane. Furthermore, outside the target area is measured an amount corresponding to 10% of the amount within the target area. Based on measurements in reference (8).

Calculating these percentages of waste of all 10 measured distributions (subsections) from the spreader, one can represent the measured waste of salt in a diagram, see figure 4. The waste due to imbalance must of course be allowed to be expressed as positive as well as negative values representing overdoses on the left-handed respectively the right-handed lane.

The diagram in figure 4 seems to express that the particular spreader tends to overdose a larger percentage when the spreading-width is increased (larger boxes on the figure). On the other hand, the dosage spread per square-meter (color of the boxes) does not influence the waste-amount for this spreader.

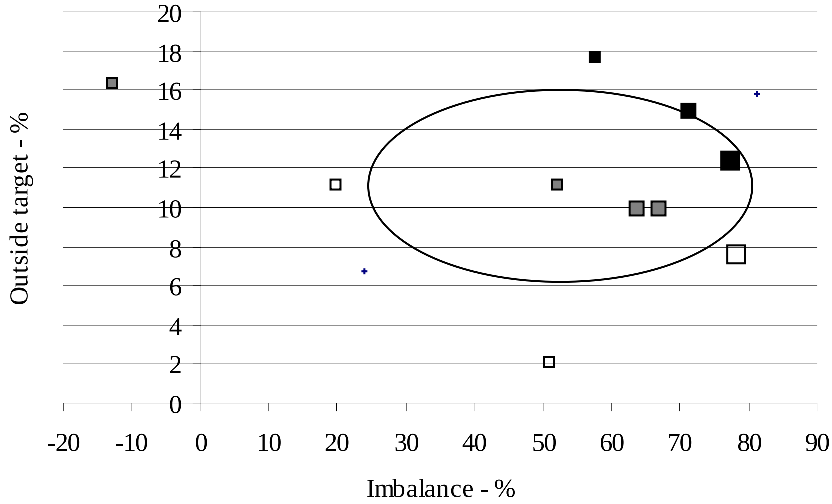

FIGURE 4 Percentage of measured salt wasted due to imbalance (overdose in one of the lanes) and due to spreading outside the target when using spreader B (from figure 2). The dose has been 5 grams pre-wetted salt per m^2 (□), 10 grams pre-wetted salt per m^2 (■) and 15 grams pre-wetted salt per m^2 (■). Spreading velocity was 60 km/hour, and spreading width was 4, 5, 6 and 7 meters (size of boxes). Based on measurements in reference (8).

It is tempting to consider that the two waste-percentages should follow normal-distributions and thus to determine their averages and standard deviations in order to compare with results from other spreaders. The values are expressed by the error-ellipse on figure 4. The principle axes of the ellipse represent the standard deviations on the two axes. When spreading repeatability is good they should vanish. The center of the ellipse represents the averages. When spreading accuracy is high the center should be at the intersection of the “imbalance”- and the “outside target”-axes.

Indeed, to assume the waste-percentages to be Gaussian is not safe. There may still be factors, influencing in a systematic or correlative way upon the waste-fractions. These factors should be recognized and eliminated. Despite of this, the normal-distribution is found to provide a reasonable and adequate set-off when trying to describe the “spreading quality”.

Table 1 and table 2 give the calculated results from all the spreaders tested. In table 1 the average and standard deviation of the imbalance (overdose in one of the lanes) is shown. Note, that the number of measurements (N) not in all cases equals 10, meaning that some of the measurements have dealt with spreading in only one lane (3 meters width).

Similar table 2 shows average and standard deviation of measured salt spread outside the target area. The number of measurements (N) is lower than 10, when some of the tests have involved spreading in a width broader than the highway’s two lanes (8 meters or above).

TABLE 1 Average and standard deviation of imbalance (overdose in one of the lanes), expressed as percentage of the salt measured within the target area. Based on measurements in references (7)…(15).

Spreader	Technology	Ice control agent	N[2)]	Average[3)]	St. Deviation
A	Rotating plate	Pre-wetted salt	10	30%	20%
B	Rotating plate	Pre-wetted salt	10	53%	29%
C	Rotating plate	Both	7	-17%	21%
D-1[1)]	Rotating plate and nozzles	Both	8	24%	33%
D-2[1)]	Rotating plate and nozzles	Both	8	20%	51%
E-1[1)]	Nozzles	Brine	7	4%	17%
E-2[1)]	Nozzles	Brine	7	3%	23%
F	Nozzles	Brine	7	7%	11%
G	Nozzles	Brine	10	-21%	23%
H-1[1)]	Nozzles	Brine	10	-3%	17%
H-2[1)]	Nozzles	Brine	10	-7%	18%

Note 1: *Two series of measurements was carried out with spreaders D, E and H.* ***Note 2:*** *N is the number of measurements (subsections) taken into account.* ***Note 3:*** *When the average expressed has a negative value it means that the lesser salt was measured in the left-hand lane.*

TABLE 2 Average and standard deviation of measured salt spread outside the target area, expressed as percentage of salt measured within the target area. Based on measurements in references (7)…(15).

Spreader	Technology	Ice control agent	N[2)]	Average	St. Deviation
A	Rotating plate	Pre-wetted salt	10	15%	15%
B	Rotating plate	Pre-wetted salt	10	11%	4%
C	Rotating plate	Both	8	26%	14%
D-1[1)]	Rotating plate and nozzles	Both	9	29%	60%
D-2[1)]	Rotating plate and nozzles	Both	7	27%	46%
E-1[1)]	Nozzles	Brine	7	29%	10%
E-2[1)]	Nozzles	Brine	10	41%	32%
F	Nozzles	Brine	8	13%	7%
G	Nozzles	Brine	8	9%	4%
H-1[1)]	Nozzles	Brine	10	11%	4%
H-2[1)]	Nozzles	Brine	10	7%	5%

Note 1: *Two series of measurements was carried out with spreaders D, E and H.* ***Note 2:*** *N is the number of measurements (subsections) taken into account.*

DISCUSSION OF "QUALITY" IN SPREADING

Spreading Quality

Looking into the values thus calculated it can be suggested to use the standard deviation of imbalance to express how good a quality of distribution each spreader is able to deliver. All the values calculated represent various aspects of the quality of the measured distribution. However not all of them are suitable to be used as an expression.

Agent Outside Target Area

The values, average and standard deviation, concerning the measurements outside the target area, are influenced from a kind of truncation. It has only been possible to measure the residual salt within the paved limits of the highway used for the tests, i.e. within a width of 7.5 meters (24½ feet). An unknown amount of salt has been spread outside this area as well. Consequently the values calculated are influenced by the setting up of the test.

Furthermore, the amount of salt spread outside the target area is not likely to be found by direct measurements at a normal operation of ice control activity. On a normal highway salt will end up in the verge or in the drainage system and can not be measured. The waste of salt spread outside the target area will have to be found indirectly, as in the studies carried out in 1998 -1999, (2).

Finally, of course, the amount of salt distributed outside the target area, gives no indications of the spreading pattern on the road surface.

Average of Imbalance

The average of the spreaders' imbalance within the target area would at first sight be an obvious choice as quality parameter, as it expresses how much more salt one has to expect in the most provided lane. Normally one will aim for a uniform distribution of the ice control agent across the cross-section. There may however be situations where an imbalanced pattern is preferred – differentiating the dosage on the right- and the left-hand lanes on motorways is one example. In such situations both dosages should to be brought into the calculations. Similarly, the highways' side gradient means that water with salt will travel from the higher side to the lower. Taking this into account one should spread the more at the higher side of that particular cross-section.

The average of imbalance can however be seen more as an expression of the quality of the adjustment of the spreader than as an expression of the spreaders' ability. The spreaders had, as mentioned, been adjusted by the manufactures' staff before FAVs measurements took place, so it is not likely that mal-calibration should have influenced the data obtained. However, in principle it should be possible to readjust the equipment and thus eliminate the spreaders' systematic imbalance. Ideally, to do so one will have to carry out measurements to determine the distribution at various spreading speeds, various spreading widths and various dosages, all representing normal situations of the road network on which the particular spreader is supposed to for operate.

This is not a small request, but it would save the environment from some of the impact from salt spread not doing any good. And it leads to considering the importance of finding simple methods to verify the calibration and, when necessary, to re-adjust the equipment, cf. figure 5.

FIGURE 5 FAV's site for verification of nozzle-spreaders. Tubs are placed on the 10 marked fields, one for each of the nozzles. The amount and distribution of brine spread within a period of time is established simply by weighing or by measuring the height of the liquid in each tub.

Standard Deviation of Imbalance

The standard deviation of each spreader's imbalance, on the other hand, expresses an uncertainty one can not easily avoid. It expresses each spreader's ability to adapt to the various situations along the road, e.g. width and speed-limits, and to the spreader's ability to adapt to the dosage called for by the various situations during a winter-season.

Assuming an optimal adjustment of the spreader the standard deviation of the imbalance in the distribution still have to be taken into account when planning and deciding the dosage to be used in a specific ice control activity. It represents a stochastic element. When the right dosage of salt needed to melt or to prevent ice bonding on the road surface have been found, one will have to add the standard deviation one, two or more times to be sure that it is likely that the right amount of salt is distributed to all the various cross-sections of the road.

A Scenario Illustrating the Importance of "Spreading Quality"

The need of focusing and improving the "quality" in spreading, i.e. the standard deviation of waste due to imbalance, can be illustrated by a scenario based on the findings of FAV.

Table 3 presents key figures from the scenario. A Danish "normal" winter is assumed, involving 85 actions leading to residual salt (pure *NaCl*) in the range from 2–9 g/m^2. A road-network of 7.2 km^2 (2.8 mi^2) approximately like the highways in the former county of Funen is considered; it is assumed that the roads are classified in two classes, meaning that winter maintenance does not have to take place simultaneously on all roads but can be fulfilled by appointing the spreaders to two routes each. The number of spreaders needed to operate the network is calculated from the effective capacity of the spreaders and the dosage necessary to meet the maximum amount of residual salt (9 g/m^2).

To find the dosages corrections are made for the loss of ice control agent 0-2 hours after spreading, cf. (2). Furthermore the scenario assumes that the spreaders have been adjusted as well as possible, meaning one does not have to take into account any waste due to systematic imbalance. The “spreading quality”, i.e. the standard deviation due to imbalance, however, is considered. This is done by raising the dosages so road-sections having an imbalance on *n* times (*n* = 0–2) the standard deviation (cf. table 2) will still have received the dosage necessary in the lesser provided lane. Setting *n* = 1 means that 95% of the road-sections will have sufficient ice control agent spread in both lanes.

Table 3 presents the results for treatment with pre-wetted salt spread by rotating plates respectively with nozzle-spread brine using FAV’s most modern equipment. Setting *n* = 1 means that the amount of pure salt is 45% higher when using pre-wetted salt, and the amount of salt wasted without doing any good at all is over four times as high compared to the nozzle-spread brine. These percentages raise as *n* is raised.

Looking at the expenditure a rotating plate spreader are cheaper to buy than a nozzle-spreader, but taking into account the price of the aggregates used one will find that the expenses per km becomes somewhat higher when using rotating plate technology. The expenses to aggregates will depend upon the logistics laid out for the winter maintenance, i.e. number and location of salt barns and mixing plants. The expenses to the contractors will depend on the number of spreaders to be used, since salaries for drivers and price to hire the vehicles will be the same whichever spreading methodology is used. The calculated scenario showed that using pre-wetted salt is 30% more costly compared to nozzle-spread brine with *n* = 1. Setting *n* = 0 will mean that the disadvantage falls to 20%, while *n* = 2 makes the disadvantage of the pre-wetted salt to raise.

Indeed, the scenario shows that the spreading quality, i.e. the standard deviation due to imbalance, is essential to minimizing the expenditures as well as to reduce the impact of salt on the environment. Highway authorities have to be observant to this parameter when buying new spreaders, and they should focus on having their spreaders adjusted correctly.

TABLE 3 Key figures from a scenario where a road network (1000 km length, 7.2 m width) is treated with pre-wetted salt respectively with brine in a "normal" year. Data concerning the spreaders are the findings of FAV. Note: 1 km = 0.62 miles. 1 Mg = 1.10 short tons.

	Spreading: Residual salt plus n × σ	n = 0	n = 1	n = 2
Rotating plate	Number of spreaders	9	10	12
	Amount of *NaCl* used per km in a "normal" year	3.75 Mg	4.41 Mg	5.36 Mg
	Amount of *NaCl* wasted per km in a "normal" year	1.31 Mg	1.97 Mg	2.92 Mg
	Percentage wasted	35%	45%	55%
Nozzles	Number of spreaders	9	10	10
	Amount of *NaCl* used per km in a "normal" year	2.89 Mg	3.04 Mg	3.21 Mg
	Amount of *NaCl* wasted per km in a "normal" year	0.29 Mg	0.44 Mg	0.61 Mg
	Percentage wasted	10%	15%	19%

Calculation based on following parameters:	***Rotating plate***	***Nozzles***
Residual salt on road after 2 hours, cf (2)	*65%*	*90%*
Standard deviation, σ, due to imbalance, cf. table 2	*15%*	*5%*
Salt- respectively brine-volume (capacity)	*2 + 5* m^3	*14* m^3
Effectively capacity	*90%*	*97%*
Cost price per spreader (2005-prices in 2008-level)	*29,000 €*	*42,000 €*
Brine: 23%.		
Interests: 5%. Writing off: 10 years. Salt: 0.58 € per Mg (2008). Water: 14.4 € per 1.000 m^3 *(2008).*		

Room for Improvements

As mentioned the measurements carried out by FAV were determined to be used in operational decision-making, not as contribution to research in the field. Consequently it is hard to turn the results into 'hard' conclusions. The methodology developed and the results obtained, however, inspire to recommend similar and supplementary investigations along the same concept.

The findings indicate that nozzles provide better spreading quality than rotating plates. In the scenario the standard deviations due to imbalance are adapted from the findings of FAV, cf. table 2 (spreader G-H respectively A-C). A measuring programme designed to gain more comparable results should be designed to control these values.

Assuming it becomes possible to control and optimize the "spreading quality", the highway authorities will be able to take advantage of knowledge on how the side gradient of the cross-sections influences on the optimal spreading pattern and how various types of pavement may call for differentiation in the dosage. These parameters, related to the road-network, can be introduced by using *GPS*-controlled spreading, meaning that the drivers can concentrate on driving the spreaders and letting a computer control the changes in the spreading pattern. The effects and savings available by introducing these technologies are not obtainable as long as the "quality" is not under control.

CONCLUSIONS

Spreading Quality

Using traditional spreading techniques one has to accept that half the amount of ice control agents consumed do not have any effect. Some of the salt is not present any longer at the road surface 2 hours after spreading; some of it is distributed so that parts of the road is over-dosed while other parts may be in need.

Focus on the “spreading quality” of spreaders is important in order to reduce the amount of salt wasted in the winter maintenance – and to reduce expenses.

“Quality” can be measured using the rather simple technology of salinity testers, and can be expressed by means of the standard deviation of the waste of salt due to imbalance in the achieved spreading patterns. The procedure laid down by FAV can be followed, however when planning measuring tests one should address the relevant factors more carefully making sure that the results are comparable.

The road authorities should focus on the “spreading quality” when ordering new spreaders, they should be aware of the stability in the spreaders adjustments, and they should introduce simple tests to verify that the adjustment, and thus the “quality”, of each spreader is remained throughout the winter season.

Need for Research and Development

Research in the influence various types of pavements have on the optimal dosage of salt is needed in order to take full advantage of the “spreading quality” available.

Research is also needed to establish a model to describe the run-off of salt and brine due to the influence of the side gradient. The model should make it possible to determine how biased the spreading pattern should be in order to minimize the dosage. This will make it possible to optimize the spreading, especially when using *GPS*-controlled spreading.

As mentioned, research is needed to determine whether the deviations from the ideal spreading-pattern are indeed Gaussian.

Finally, of course, research is needed to establish better knowledge on how much (or how little) salt one actually needs to dosage at typical winter-situations.

Final Remarks

Until the turn of the year 2006-07 Denmark had three levels of highway authorities. The Danish Road Directorate managed the national highways. The county councils managed the county highways (on Funen 1.011 km), and the municipalities were in charge of the local road network.

January 1st 2007 the local Danish administration was renewed. The reorganisation closed down the Danish counties, and their obligations were distributed among new actors.

FAV’s studies of the use of brine are not prolonged, and FAV never had the opportunity to continue its analysis.

Acknowledgment

Thanks to all employees at Fyns Amts Vejvæsen who took part in the process of improving the winter maintenance activities. Thanks to the County Council of Funen and to the County’s board of directors for spacious working conditions and faith and courage to try new approaches – without such attitudes no improvements would be possible.

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